A High Throughput Bending-Magnet Beamline for Soft X-Ray Spectro-Microscopy at the ALS: Design and Performance

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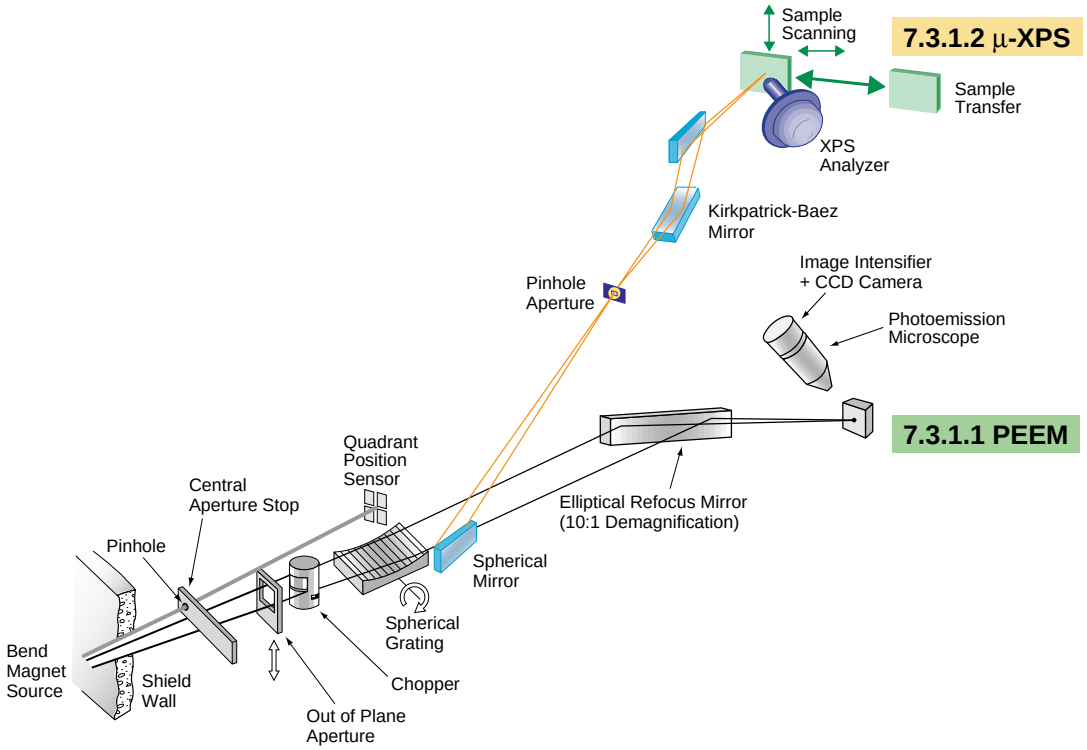
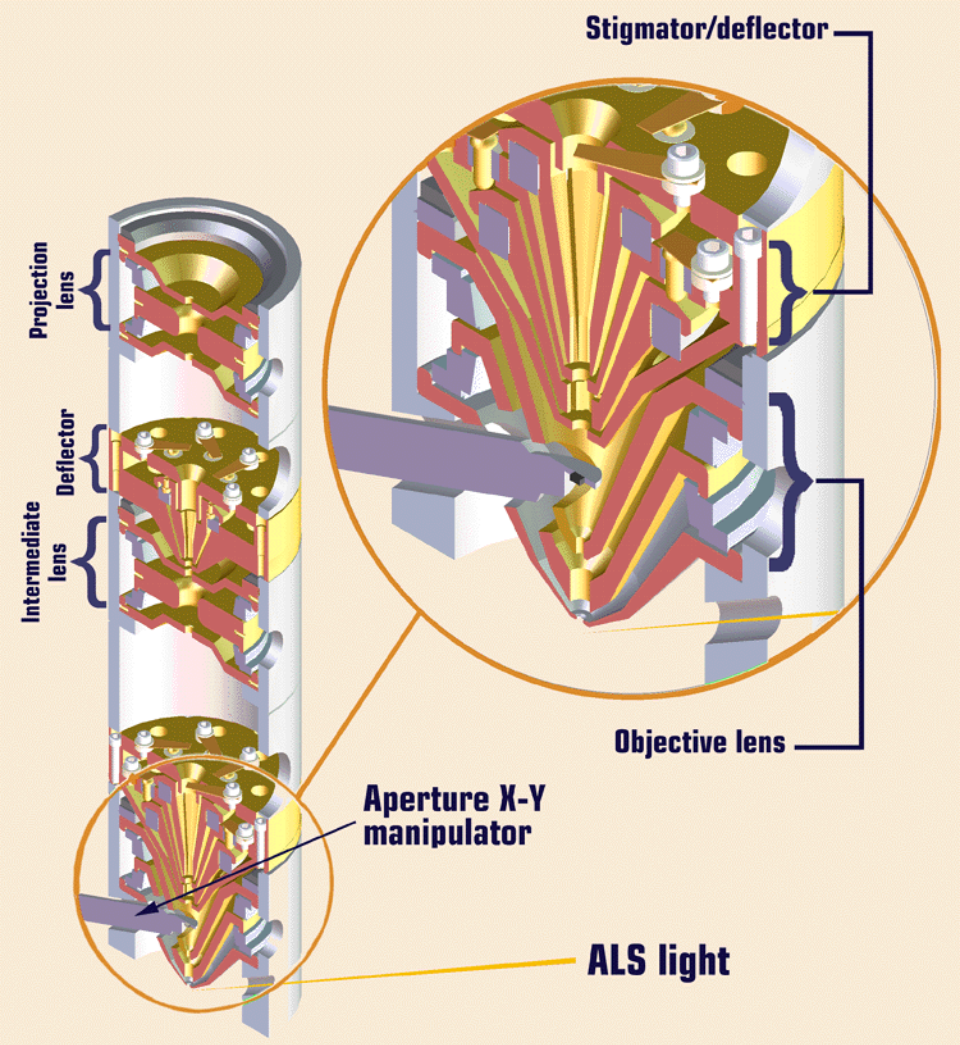


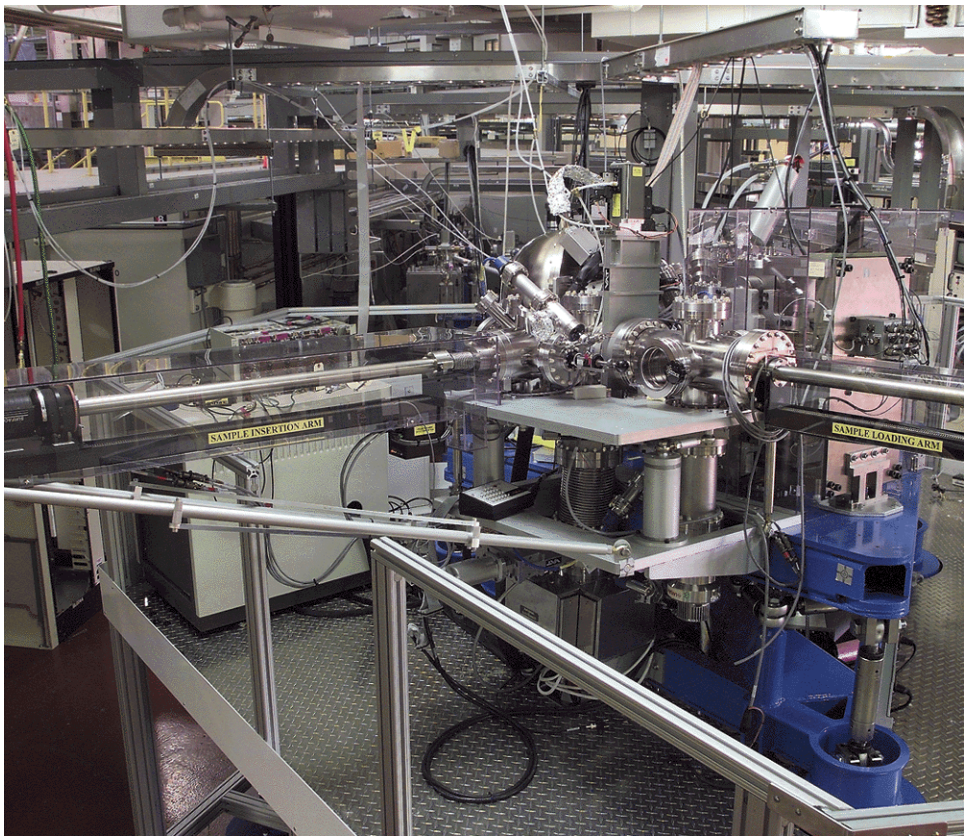
Optical layout of Beamline 7.3.1

Beamline 7.3.1 is a facility for Scanning Micro photoelectron spectroscopy (μXPS) and X-ray photoemission microscopy (PEEM) . The beam line uses an entrance slit-less monochromator of low dispersion with a source-size limited resolving power of 1600 at 800 eV to provide monochromatic soft rays (200 to 1250 eV) from a bending magnet source. The beamline, after the monochromator, diverges into two branch lines: one for scanning, micro-focused x-ray photoelectron spectroscopy (μXPS) that accepts 0.2 milliradians of the bend magnet fan to provide a flux of ≈3 x 10^9 photons / sec at 800 eV, and the second for full field photoelectron emission microscopy (PEEM) which utilizes 2.0 milliradians to provide ≈2 x 10^{12} photon/sec at 800 eV into an illuminated field of < 35 μm.



A CAD drawing of PEEM II, Full Field Photo Emission Microscope

Beamline 7.3.1.1, PEEM. The Photoemission Electron Microscope was developed for full field imaging of magnetic materials. These measurements depend on the differential adsorption of circularly polarized light (magnetic circular dichroism, or MCD). A mask and a mechanical chopper are incorporated into the beamline before the monochromater grating to allow switching between the left and right circularly polarized light found above and below the center of the radiation fan. A 1.1 meter elliptical refocusing mirror takes the light after the monochrometer and focuses it on to the sample with a spot size <35 μm.



Beamline 7.3.1.2 μXPS endstation

Beamline 7.3.1.2, μXPS. The μXPS branch line was created specifically for analyzing the micro structures in integrated circuits and the silicon wafers from which they are made. A small portion of the light from the monochrometer (≈ .2 milliradians) is focused onto an entrance slit by a bendable refocusing mirror. A pair of elliptically bent mirrors (in a Kirkpatrick-Baez arrangement) in the μXPS chamber focuses the light from the slits to a spot size of <2 by 2 μm on the sample. Photon flux at the sample is ≈3 X 10^9 photons / second and energy resolution is typically <.5 eV at 850 eV photon energy.

Inside the μXPS chamber is a mechanical stage, capable of accepting samples up to 50 by 50 mm, and positioning any portion of the sample under the photon beam to micron accuracy . Samples are introduced into the μXPS chamber by a semi-automatic sample transfer system. Provision has been made for limited sample preparation in a UHV sample preparation chamber, immediately adjacent to the main μXPS chamber. A sample can also be mapped or fiducialized prior to introduction into the system, simplifying navigation. There is also an off-axis, high resolution, optical microscope in the μXPS chamber for direct observation of samples.

Once positioned, the samples can be analyzed either by XPS using a commercial electron analyzer (PHI) or by XANES (using the electron analyzer or sample drain current). The ability to do both XPS and Xanes provides great flexibility in sample analyses. Images based on elemental, chemical or topological contrast can be created by rastering the sample under the photon beam using either XPS or XANES. Data from scans are automatically saved and archived and are accessible for transfer or off line analysis. XPS spectral data may be analyzed using PHI Multi-pac software.

We presently have an Argon sputter gun for surface cleaning and depth profiling and an electron flood gun for sample charge neutralization in place as well as a commercial hard x-ray (Al- and Mg-Ka) source. We are in the process of acquiring a new sample charge neutralizing system which will allow us to perform chemical analyses on insulating samples such as polymers.

To date we have demonstrated the ability to find and perform elemental [1] and chemical [2] analyses on small ($\approx 2 \times 5$ micron) particles . Overall performance and accessibility, including "user friendliness", have been favorably compared with commercial XPS instruments[3]

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[1]G.D. Ackerman, R. Duarte, K. Franck, M.R. Howells, Z. Hussain, S. Irick, A. Johnson, G. Morrison, H.A. Padmore, S.-Y. Rah, T. Renner, B. Sheridan, W. Steele, C. Ayre, H. Fujimoto, F. Gozzo, B.B. Triplett, R.X. Ynzunza,P.D. Kinney, Y.S. Yuritsky, Presented at the 1998 MRS Spring Meeting, San Francisco CA, 1998

[2] F. Gozzo, B. Triplett, H. Fujimoto, P. Coon, C. Ayre, P.D. Kinney, Y.S. Yuritsky, G.D. Ackerman, A. Johnson,H. Padmore T. Renner, B. Sheridan, W. Steele, Z. Hussain, Presented at the 1998 MRS Spring Meeting, San Francisco CA, 1998

[3] Y.S. Yuritsky, P.D. Kinney, E. L. Principe, I. Mowat and L.Craig, Presented at the 1998 MRS Spring Meeting, San Francisco CA, 1998

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